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LYSOMETRIC INVESTIGATIONS ON HOG FARM MANURE LAND DISPOSAL

The author conducted a lysometric experiment in which meadow of light soil was irrigated with manure coming from a hog farm. During the one-year experiment diluted manure was applied in doses amounting to 12.5, 25, 37.5, 50 and 60 mm, while the total annual loading of full manure (non-diluted) amounted to 10, 20, 30, 40 and 50 mm. In the second experiment lasting for 3 years the separate doses of diluted manure containing 2.5 and 5 mm of full manure, amounted to 40 mm, the total annual loading of full manure being 5, 10, 15 and 20 mm. After irrigation with 50 and 63.5 mm doses of manure the leachate contained high concentrations of nitrogen and displayed the features of strong pollution. With 10 mm and lower doses of the manure the leachate was clear. The results obtained allow to infer that both the land disposal of the manure and the reduction in the content of its individual pollutants depend on the separate doses of manure and its annual loading.

1. INTRODUCTION

Running of large-size cattle-and hog-farms is closely connected with a much important and difficult problem consisting in utilization of manure. It is generally considered that manure, being a natural fertilizer produced in breeding farms, should serve agricultural purposes. This opinion is supported by two reasons, namely by the necessity of intensification of field, meadow, and pasture crops providing the indispensable forage for the animals, and by the purification of manure occurring in soil, thus by the protection of open and underground waters against pollution. Hence the manure should be utilized in agriculture, and its artifical treatment admitted only in cases of too high density of livestock, not sufficiently large area of arable land, tightness of soil and so on.

Manure, even highly diluted, contains large amounts of pollutants, of which the most important from the water protection viewpoint are organic compounds, nitrogen, phosphorus, pathogenic microorganisms, alimentary tract parasites and their eggs. The remaining mineral compounds, such as K_2O, CaO, NaO_2, Cl^-, SO_4^{--}, MgO, — apart from

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increasing the concentration of salts in open and underground water — do not perform any essential role.

It has been generally assumed that BOD_5 is the appropriate cryterion in evaluation of the degree of total pollution caused chiefly by compounds contained in liquid manure, wastes and other waters, and that nitrogen and phosphorus are the indicators of mineral pollution, since these elements are the main biogenic components which — even in mineralized form — lead to a secondary pollution of open waters. Sanitary evaluation is usually done by coli tests [3, 5].

2. DESIGN AND METHODS OF EXPERIMENTS

Lysometric investigations on the land disposal of liquid manure from hog farm were performed in the Wrocław Section of the Institute of Melioration and Grasslands in 1972–1975. Lysometers of the area of 1.13 m^2 and depth of 1.37 m filled with light soil were sodded with various species of grass. The one-year experiment carried out in 1972 comprised the following combinations in three replications (the last combination with the highest loading of manure had no replication):

1. Pure water in doses of 40 mm $\times$4 + NPK 280+100+200 kg/ha,
2. manure 2.5 mm diluted with water to 12.5 mm $\times$4,
3. ,, 5 mm ,, ,, ,, ,, 25 mm $\times$4,
4. ,, 7.5 mm ,, ,, ,, ,, 37.5 mm $\times$4,
5. ,, 10 mm ,, ,, ,, ,, 50 mm $\times$4,
6. ,, 12.5 mm ,, ,, ,, ,, 62.55 mm $\times$4.

Annual loading with full manure amounted to 10, 20, 30, 40 and 50 mm. Each swatch of grass was irrigated only once. Each combination was irrigated with the same concentration of liquid manure applied in different doses.

The assumed manure loading being found to be too high, the experiment was stopped after one year. The results obtained are presented in figs. 1, 3, 5. Thereupon the soil in lysometers was washed with well water, and after spring precipitations a new experiment was started. The doses of full manure were 2.5 and 5 mm, while the annual loading amounted to 5, 10, 15 and 20 mm. Lysometers were irrigated with liquid manure and pure water. The design of the experiment is presented in table 1.

The analyses performed systematically in the course of the experiment (3 years) covered: manure and well water used for irrigation, the leachate, and grass in each swatch. Results obtained for the balanse of the components determined, water balance and the results of soil analysis (made after the experiment was completed), have been presented in the separate paper [8]. In this paper the author is concerned only with the main pollution parameters for the manure and leachate, i. e. BOD_5, nitrogen and phosphorus. The residue after evaporation, which characterizes the sum of mineral components in the leachate, and the sum of mineral and organic components in the manure, and water balanse have been presented additionally.

3. DISCUSSION OF RESULTS

3.1. BIOCHEMICAL OXYGEN DEMAND

In liquid manure — like in most wastewater, the highest demand for oxygen is displayed by carbon — the main component of organic matter, and by nitrogen — whose organic and ammonium forms are oxidized to nitrates under aerobic conditions. Theoretically, aerobic conditions should prevail in the soil, thus BOD of liquid manure (the sum of oxygen demand of carbon, nitrogen and other components) should be in equilibrium with respect to the oxygen getting into the soil.

Atmospheric oxygen penetrates the soil in different ways: being dissolved in manure (insignificant quantities), and sucked during percolation of liquid manure. After filtration and percolation of liquid manure are finished atmospheric oxygen enters the soil by air diffusion. The depth of its penetration into the soil is limited and usually does not exceed 1 m [2]. The exchange of soil and atmospheric air is strongly influenced by temperature variations. In day time, when the soil is warmed, soil air rich in CO_2 enters the atmosphere, while in night, when the temperature drops, atmospheric air cool and rich in oxygen enters the soil. In the common language this process is called ,,respiration of the soil".

The value of BOD_5 in full manure from hog farm is very high reaching 30,000 mg/dm^3 [1]. In diluted manure this value is several times lower and depends on the dilution degree. In manure which was used for irrigations in 1972, and whose concentration was identical for all the combinations, the value of BOD_5 ranged from 1500 to 3480 mg/dm^3 (fig. 1). In 1973–1975 the concentrations of liquid manure used for irrigations were different (table 1), and the values of BOD_5 amounted to 1100–1600, 2200–4000, and 6000–14200 mg/dm^3, depending on the dilution degree.

Since in 1972 the doses of liquid manure were different (from 12.5 to 62.5 mm) the leachate was a mixture of different volumes of liquid manure and water. Hence, liquid manure equally polluted but applied in different hydraulic loading, after being filtrated through the soil, gave the effluent with different values of BOD_5.

In the leachate from the soil fertilized with NPK and irrigated with 40 mm doses of pure water BOD_5 varied from 1.2 to 2 mg/dm^3. In the leachate from the soil irrigated with 12.5, 25, 37.5, 50 and 60 mm doses of diluted manure the corresponding values of BOD_5 amounted to 1.4–8, 1.4–45, 9.6–95, 64–207, and 130–480 mg/dm^3, respectively (The leachate from the soil irrigated with 12.5 and 25 mm doses of liquid manure has been observed only when the irrigation was applied to a strongly moistened soil, or was followed by precipitation.) The results obtained indicate that the BOD_5 value of the leachate from the soil increased remarkably with the increasing BOD_5 and doses of liquid manure. This relationship is presented in fig. 1.

High values of BOD_5 found in the leachate from the soil indicate that diluted manure used in 50 and 62.5 mm doses was not satisfactorily purified in the soil. In the fourth irrigation in which the BOD_5 of liquid manure amounted to 3400 mg/dm^3, and concentration of nitrogen was 1672 mg/dm^3, the leachate had an unpleasant odour, and grey colour

Table 1

Design of irrigations for the individual combinations of the experiments carried out in the years 1973–1975

Combination	Number and quantity of single doses of manure in and water in:			Annual dose of diluted manure an water in mm
	vegetation	late autumn	early spring	
Water + NPK (280+100+ +200 kg)	4×40 mm	—	—	160
Manure Water	2×2.5 mm 2×40 mm	— —	— —	80 80
Manure Water	2×2.5 mm 2×40 mm	1×5 mm —	— —	100 80
Manure Water	1×5 mm 3×40 mm	1×5 mm —	1×5 mm —	80 120
Manure Water	2×5 mm 2×40 mm	1×5 mm —	1×5 mm —	120 80
Single doses of diluted manure	40 mm	20 mm	20 mm	

* Irrigations were done with diluted manure, 40 mm doses of diluted manure, applied in vegetation season contained 2.5 mm of full manure +37.5 mm of water (dilution 1+15) and 5 mm of full manure +35 mm of water (dilution 1+7). In late autumn and early spring the 20 mm doses of diluted manure contained 5 mm of full manure + 15 mm of water (dilution 1+3). The concentration of nitrogen contained in manure was the indicator of its dilution.

resembling that of municipal wastes. High BOD_5 of this effluent confirms its inadequate purification in the irrigated soil.

In all the combinations of the experiment conducted in 1973–1975 the diluted manure was given in identical doses amounting to 40 mm, but in different (1+15 and 1+7) dilutions (200 mm dose of the manure diluted in 1+3 ratio gave no leachate) the highest value of BOD_5 in the leachate amounted to only 170 mg/dm^3, and the highest annual average of BOD_5 was 19.7 mg/dm^3. Total purification of the manure in soil was much better if compared with the experiment conducted in 1972. The leachate from the soil was always clear and had neither unpleasant odour nor suspensions.

The degree of BOD reduction of the manure in soil was very high and amounted to 99.5–99.7% (table 2). (For the experiment conducted in 1972 the reduction of BOD_5 and of other components of the manure was not calculated, since the experiment lasted for less than one year.)

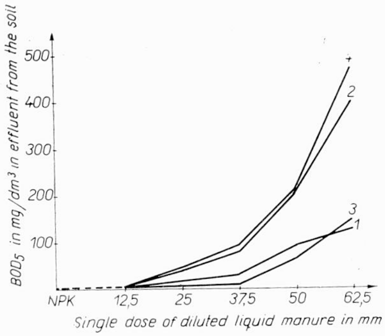

Fig. 1. BOD_5 in mg/dm^3 in the leachate from the soil versus the doses of manure

1, 2, 3 4 — the leachate from the soil after consecutive irrigations with manure, with the following values of BOD_5: *1* — 1500 *2* — 1700, *3* — 1500, *4* — 3480 mg/dm^3

Rys. 1. BZT_5 w mg/dm^3 w odcieku z gleby w zależności od wysokości dawek gnojowicy

1, 2, 3, 4 — odciek z gleby po kolejnych nawodnieniach gnojowicą, o następujących wartościach BZT_5: *1* — 1500, *2* — 1700, *3* — 1500, *4* — 3480 mg/dm^3

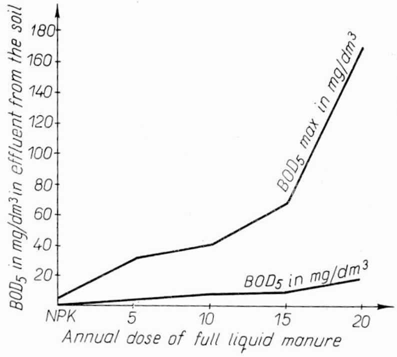

Fig. 2. Maximal and annual means of the BOD_5 values in mg/dm^3 in the leachate from the soil vs. the doses of full manure. Annual dose of full manure in mm

Rys. 2. Maksymalne i średnie roczne wartości BZT_5 w mg/dm^3 w odcieku z gleby w zależności od wysokości dawek gnojowicy pełnej

Table 2

Means (from 3 years) of the quantities of components (in g/m^2) introduced into the soil with fertilizers, pure water and manure during a year, and discharged to the leachate from the soil of lysometers

Combination		N	P_2O_5	K_2O	Remained after evaporation	BOD_5
Pure water + NPK	1	33.0	10.3	24.8	161.5	0.6
	2	2.7	0.1	4.1	221.5	0.2
	r%	91.8	99.0	83.5	−37.2	66.7
5 mm of full manure	1	26.0	12.2	19.9	286.3	117.0
	2	5.0	0.07	4.2	255.7	0.6
	r%	80.8	99.4	78.9	10.7	99.5
10 mm of full manure	1	47.7	18.2	35.1	541.2	257.2
	2	14.9	0.1	5.3	405.8	1.0
	r%	68.8	99.5	84.9	25.0	99.6
15 mm of full manure	1	71.4	28.5	50.2	773.6	426.4
	2	24.5	0.1	8.2	513.3	1.3
	r%	65.7	99.6	83.7	33.6	99.7
20 mm of full manure	1	94.2	43.0	66.0	1042.3	555.5
	2	37.4	0.2	10.3	683.9	2.1
	r%	60.3	99.5	84.4	34.4	99.6

1 — components introduced into the soil,
2 — components discharged to the effluent,
r% — purification degree.

3.2. NITROGEN

Concentration of nitrogen, like the concentrations of other components of the manure from pig farm, strongly varies depending in the fodder given to the animals, their age, and the amount of water consumed. The average content of nitrogen in full manure amounts to about 5000 mg/kg [7, 10]. This element appears chiefly in organic and ammonium forms. According to Koriath about 50% of nitrogen in manure is present in easily soluble form (NH_{4-}^{+}) mostly as ammonium carbonate [3, 9].

Nitrogen compounds which are introduced to soil are undergoing much complicated processes of mineralization, deactivation, and denitrification, they are uptaken by plants and washed out by precipitation. Mineralization consists in decomposition of organic nitrogen and formation of ammonium in aerobic conditions. Nitrification, in which ammonium nitrogen is getting oxidized first to nitrites and then to nitrates

$$\text{Organic nitrogen} \rightarrow NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-,$$

occurs under the same conditions.

Since the transition of nitrites into nitrates lasts for very short time, the former appear in very small quantities and is very seldom observed under aerobic conditions.

Ammonium nitrogen is readily soluble in water and gets easily into sorption complex of the soil, which prevents its lossess — provided however that its quantities do not exceed actual sorption power of the soil. Under aerobic conditions ammonium nitrate passes through nitrites into nitrates. The latter — being feebly sorbed and readily soluble in water — are washed from the soil, unless they are uptaken by plants.

Mineral nitrogen, which due to biological processes passes into organic form, becomes inaccessible and non available for plants. It is bound by the soil biomass. This process is promoted by a high C:N ratio.

Bad anaerobic conditions in soil lead to denitrification which is a rather complex process and difficult to understand. Under the influence of microbiological and chemical reactions inorganic nitrogen compounds ($NO_3^- \rightarrow NO_2^- \rightarrow NH_4^+$) pass into gaseous forms of N_2, N_2O, NO which escape to the atmosphere. Biological denitrification causes higher losses than chemical denitrification, and may also occur under aerobic conditions. According to Larson, about 15% of nitrates in soil undergoes denitrification, and when large amounts of organic compounds are applied (which is the case with liquid manure) these losses may be much greater [6].

Organic carbon (1 mg of carbon for 1 mg of nitrogen) is the energy source for denitrifing bacteria. The content of organic carbon in liquid manure is high enough for denitrification, hence considerable losses in nitrogen should be expected. These losses occur also due to a direct volatilization of ammonium during the i rigation with liquid manure [3].

In diluted manure used in irrigations the mean contents of organic and ammonium nitrogen amounted to 31.8% and 68.2%, respectively. In the manure diluted to a smaller degree the ratio of both forms shifted toward the organic nitrogen. In the leachate the nitrogen appeared chiefly in form of nitrates. The highest concentration of ammonium nitrogen in the leachate (according to the consecutive combinations) amounted to 3.5, 5.6, 6.3, 8.4, 9.8 mg/dm³. These cases were, however, only sporadically observed, and most frequently ammonium nitrogen as well as nitrites were not detected at all or only their trace amounts were found. The only exception was the leachate in lysometers irrigated with 50 and 62.5 mm doses of liquid manure in which the concentration of nitrogen amounted to 1672 mg/dm³ (experiment conducted in 1972). Besides ammonium nitrogen (whose quantities amounted to 32.5 and 51.5 mg/dm³, respectively) it contained also organic nitrogen in concentrations of 30 and 50 mg/dm³. In the above experiment the highest concentrations of nitrogen stated in the leachate (according to the increasing loading with the liquid manure) amounted to: 14.0, 17.5, 43.5, 77.2, 102.0 and 126.0 mg/dm³, the corresponding annual means being 8.3, 8.2, 21.0, 36.2, 48.2, and 56.5 mg/dm³, respectively. In the experiment carried out in the years 1973–1977 the highest concentrations of nitrogen (according to the increasing loading with liquid manure) amounted to 31.5, 74.9, 126.0, 221.0, 270.2 mg/dm³, whereas the means from three years were 13.0, 22.1, 63.6, 103.4, 148.2 mg/dm³.

The dependence of nitrogen concentration in the leachate from the soil on the applied doses of liquid manure is shown in figs. 3 and 4. The results obtained indicate that the loading of nitrogen introduced into the soil with the manure is too high with respect to the demand of plants.

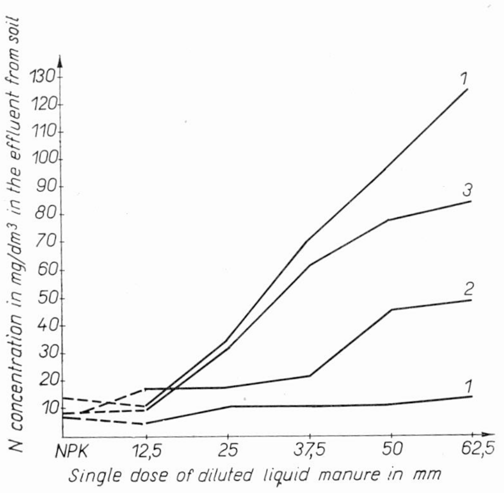

Fig. 3. Concentration of nitrogen (mg/dm³) in the leachate from the soil vs. doses of manure

1, 2, 3, 4 — the leachate from the soil after successive irrigations with manure containing the following concentrations of nitrogen: *1* — 721, *2* — 883, *3* — 414, *4* — 1672 mg/dm³

Single dose of liquid manure in mm

Rys. 3. Stężenie azotu w mg/dm³ w odcieku z gleby w zależności od wysokości dawek gnojowicy

1, 2, 3, 4 — odciek z gleby po kolejnych nawodnieniach gnojowicą o następującym stężeniu azotu: *1* — 721, *2* — 833, *3* — 414, *4* — 1672 mg/dm³

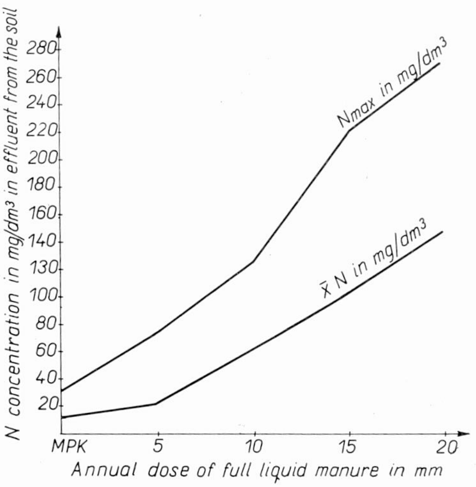

Fig. 4. Maximal and means annual concentrations of nitrogen (mg/dm³) in the leachate from the soil vs. the doses of full manure. Annual doses of full liquid manure in mm

Rys. 4. Maksymalne i średnie roczne stężenie azotu w mg/dm³ w odcieku z gleby w zależności od wysokości dawek gnojowicy pełnej

3.3. PHOSPHORUS, POTASSIUM AND OTHER MINERAL COMPONENTS

Phosphorus in manure is present chiefly in organic compounds, very rarely in form of iron, aluminium or calcium phosphates [3, 9]. After the manure is introduced into the soil phosphorus is gradually released, and during vegetation season it is uptaken by plants, while in the remaining seasons it passes into forms less accessible for plants.

The concentrations of phosphorus in full manure from hog farm — like those of nitrogen and other mineral components — is not stable, since according to some authors it amounts to about 400 mg/dm^3, and to others it does not reach 2000 mg/dm^3 [1, 7, 4]. In the manure used in experiment P_2O_5 varied from 86 to 914 mg/dm^3. In the leachate from the soil — regardless of its loading with manure and water, the concentration of P_2O_5 never exceeded 0.5 mg/dm^3. Hence it follows that phosphorus is strongly retained in the soil.

Concentration of potassium in full manure from hog farm varies from 1500 to above 4000, on the average 3000 mg/dm^3 [7]. It is almost always present in a readily soluble form and is very quickly uptaken by the plants. In diluted manure used for irrigations of lysometers the concentration of K_2O ranged from 142 to 900 mg/dm^3. The highest concentrations found in the leachate from the soil (according to the increasing loading with liquid manure) amounted to 27.0, 33.2, 39.0, 54.0, and 71.0 mg/dm^3.

Of the remaining mineral components of the manure calcium, sodium, chlorides, and magnesium, the concentrations of Ca, Na_2O, Cl^-, and MgO amounted to 160–1600, 98–940, 138–530, and 39–72, respectively. In the soil leachate (according to the successive combinations and increasing loading with liquid manure) the following concentrations were found:

CaO : 179–345, 132–285, 130–432, 143–591, 211–675 mg/dm^3,
Na_2O : 123–187, 164–336, 183–546, 187–600, 232–780 mg/dm^3,
Cl^- : 112–187, 110–285, 120–475, 130–560, 150–640 mg/dm^3,
MgO : 24–33, 24–32, 28–51, 42–102, 46–116 mg/dm^3.

The residue — after evaporation — representing the sum of organic and mineral compounds in liquid manure, and the sum of mineral compounds in the leachate is presented in figs 5 and 6. In the manure diluted in ratios 1:15, 1:7, and 1:3 the corresponding values varied within 1450–6770, 3665–12600, and 5420–31692 mg/dm^3, respectively. In pure water used for irrigations the the residue after evaporation amounted to 730–960 mg/dm^3. In the soil leachate the residue (according to consecutive combinations) amounted to 830–1335, 920–1910, 960–2775, 1040–3820 and 1460–4645 mg/dm^3. The results presented indicate that the concentrations of mineral components in the soil leachate increases with the increasing loading of liquid manure.

It should, however, be emphasized, that the reduction of a given component, thus the degree of its purification in soil connot be stated by comparing its concentrations in leachate and in liquid manure, unless the volumes of liquid manure and leachate are considered. Since the concentrations of most components in the leachate are lower than in liquid manure, and the volume of the former is also smaller, the purification degree of

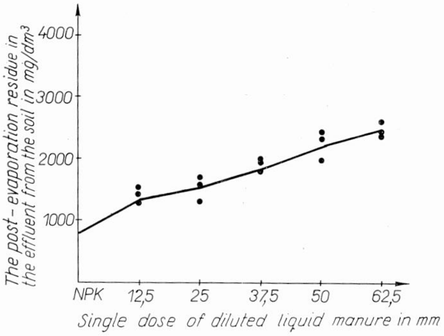

Fig. 5. The post-evaporation residue (mg/dm^3) in the leachate from the soil vs. the doses of manure

Rys. 5. Pozostałość po odparowaniu w mg/dm^3 w odcieku z gleby w zależności od wysokości dawki gnojowicy

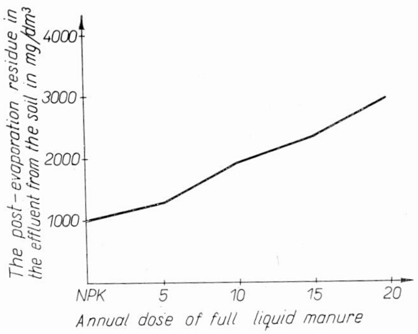

Fig. 6. The post-evaporation residue (mg/dm^3) in the effluent from the soil vs. doses of manure

Rys. 6. Pozostałość po odparowaniu w mg/dm^3 w odcieku z gleby w zależności od wysokości dawki gnojowicy

the manure is high. The mean (from three years) loadings of the most important mineral components, and of BOD_5 introduced into the soil with the manure and found in the leachate, are presented in table 2. The degree of their reduction in soil ($r\%$) corresponding to the degree of purification was calculated according to the formula

$$r\% = \frac{Q_g \cdot C_g - Q_o \cdot C_o}{Q_g C_g} \cdot 100$$

where

r — purification degree of liquid manure in %,
Q_g — liquid manure introduced into the soil in dm^3/m^2,
C_g — concentration of components in liquid manure in mg/dm^3,
Q_o — leachate from the irrigated soil in dm^3/m^2,
C_o — concentration of components in the leachate in mg/dm^3.

Water balance for the whole period of experiment is presented in table 3. The results obtained show that with identical hydraulic loading applied in all the years the amount of leachate, thus the loading of salts contained depends on precipitations.

The investigations conducted have not included bacterial pollution whose index is given by coli test. According to Krilger and Hirte these pollutants show the same tendency as chemical pollutants and depend on the manure loading [5]. At the loading from 8 LU/ha (LU — Heavy Livestock weighing 500 kg) the presence of bacterium coli in soil deeper than 60 cm was stated only sporadically, no bacterie being found in the depth exceeding 150 cm [5]. The presence of E. coli in the leachate (for the same manure loading) was stated in 15%, but in the loading two times higher (16 LU/ha) it was found in 81.1% of cases. According to those authors, the loading of soil with the manure from hog farms (4.5 LU/ha)

Table 3

Water balance in mm from 15. III. 1973 to 14. III. 1975

Year	Combination (in mm)	Precipitation			Manure + water	Precipitation + manure + water	Effluent			Annual field water consumption
		summer	winter	total			summer	winter	total	
1973	NPK	331.5	162.5	494.0	160.0	654.0	79.4	75.0	154.4	499.6
	5				160.0	654.0	80.0	76.8	156.8	497.2
	10				180.0	674.0	85.2	78.8	164.0	510.0
	15				200.0	694.0	88.0	83.1	171.1	522.9
	20				200.0	694.0	88.9	84.5	173.4	520.6
1974	NPK	413.9	298.9	712.8	160.0	872.8	86.2	146.9	233.1	639.7
	5				160.0	872.8	86.0	145.4	231.4	641.4
	10				180.0	892.8	90.5	160.3	250.8	642.0
	15				200.0	912.8	96.1	161.6	257.7	655.1
	20				200.0	912.8	99.6	161.2	260.8	652.0
1975	NPK	476.0	218.6	694.6	160.0	854.6	118.4	136.3	254.7	599.9
	5				160.0	854.6	120.5	135.5	256.0	598.6
	10				180.0	874.6	122.8	146.9	269.7	604.9
	15				200.0	894.6	123.5	162.3	285.8	608.8
	20				200.0	894.6	126.0	162.7	284.7	609.9

is safe for underground water from hygienic viewpoint. For cattle the admissible loading assumed is 6 LU/ha, and for poultry 2.5 LU/ha [11]. In late autumn or in early spring, when the biological activity of the soil is low, the total purification degree of total purification of the liquid manure decreases.

4. CONCLUSIONS

The results obtained from lysometric experiments allow to formulate the following conclusions:

1. Land disposal efficiency of manure depends on the doses applied and annual loading. The concentrations of nitrogen potassium, calcium, sodium, chlorides, magnezium, as well as the value of BOD_5 increased with the increasing loading manure. Only the concentration of phosphorus did not change its level, not exceeding 0.5 mg/dm^3.

2. Solid suspensions in 40 mm doses of the manure in dilutions (1+15) and (1+7), applied during the vegetation season, and 20 mm doses in dilution (1+3), applied in early spring and late autumn, have been completely removed, the reduction in BOD_5 value and P_2O_5 content being higher than 99.9%.

3. The reduction in nitrogen contents decreased with the increasing loading of liquid manure. With the doses of NPK amounting to 280, 100 and 200 kg/ha, respectively, the

reduction of nitrogen was 91.8%, while with the irrigation with liquid manure (within the range of loadings with full manure amounting to 5, 10, 15 and 20 mm) it amounted to 80.8, 68.2, 65.7, and 60.3%, respectively. In liquid manure nitrogen appeared in organic and ammonium forms, while in the leachate it appeared chiefly in form of nitrates.

4. The loading of soil with liquid manure did not/or slightly affected the reduction of potassium content, which varied from 78.9 to 84.9%.

5. For identical doses of liquid manure applied during all the years of experiment the leachate and the contents of salts strongly depended on precipitations.

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BADANIA NAD OCZYSZCZANIEM W GLEBIE GNOJOWICY Z FERMY ŚWIŃ

Autor przeprowadził doświadczenie lizometryczne z nawodnieniem łąki na glebie lekkiej gnojowicą z fermy świń. Trwające 1 rok doświadczenie składało się z następujących kombinacji: NPK-280+100+200 kg/ha, 10, 20, 30, 40 i 50 mm gnojowicy pełnej na rok. Stosowana do nawodnień gnojowica występowała w rozcieńczeniu, a wysokość pojedynczych dawek wynosiła 12,5, 25, 37,5, 50 i 62,5 mm. Doświadczenie trwające przez kolejne 3 lata miało następujące kombinacje: NPK-280+100+200 kg/ha, 5, 10, 15 i 20 mm gnojowicy pełnej na rok. Nawodnienia prowadzono 40 mm dawkami gnojowicy rozcieńczonej, które zawierały 2,5 i 5 mm gnojowicy pełnej (rozcieńczenie 1+15 i 1+7) a w okresie przedwiośnia i późnej jesieni 20 mm dawkami gnojowicy rozcieńczonej, zawierającej 5 mm gnojowicy pełnej (rozcieńczenie 1+3).

Odciek z gleby po nawodnieniu 50 i 62,5 mm dawkami gnojowicy, której BZT_5 wynosiło 3480 mg/dm^3, a stężenie azotu 1672 mg/dm^3, był bardzo zanieczyszczony. Jego BZT_5 wynosiło 480 mg/dm^3, a azot występował głównie w formie organicznej i amonowej. Odciek ten miał szarą barwę ścieków miejskich i nie-

przyjemny zapach. W trzyletnim doświadczeniu, w którym stosowano pojedyncze 40 mm dawki gnojowicy, a obciążenie gleby gnojowicą było dużo mniejsze, odciek był klarowny, bez zapachu. Jego największe notowane BZT_5 wynosiło 170 mg/dm^3, a średnie roczne od 4,9 do 19,7, azot natomiast występował głównie w formie azotanów.

Uzyskane wyniki wskazują, że oczyszczenie gnojowicy w glebie zależy od wysokości stosowanych dawek i rocznego obciążenia. Równolegle ze zwiększeniem się obciążenia gleby gnojowicą, w odcieku z gleby wzrastało stężenie azotu, potasu, wapnia, sodu, chlorków i magnezu oraz BZT_5. Tylko stężenie potasu utrzymywało się na stałym poziomie i nie przekraczało 0,5 mg/dm^3. Stosowane 40 mm dawki gnojowicy rozcieńczonej zapewniły całkowite oczyszczenie gnojowicy w glebie z zawiesin części stałych oraz redukcję BZT_5 i P_2O_5 powyżej 99%. Stopień redukcji azotu był znacznie mniejszy i w zależności od wysokości obciążenia gleby gnojowicą wynosił 80,8, 68,8, 65,7, 60,2%, a przy nawodnieniu NPK — 91,8%. Wysokość obciążenia gleby gnojowicą nie miała większego wpływu na stopień redukcji potasu, który wynosił od 78,9 do 84,9%.

VERSUCHE ZUR REINIGUNG VON SCHWEINEGÜLLE IM BODEN

Der Verfasser beschickte eine begraste Lysimeteranlage, die mit leichtem Boden gefüllt war, mit Schweinegülle.

Die Erstversuche dauerten 1 Jahr und beinhaletten folgende Kombinationen: N+P+K = 280+100+200 kg/ha sowie 10,20, 30, 40 und 50 mm Gülle pro Jahr. Die Gülle wurde vor der Beschickung verdünnt und die entsprechenden Einzelgaben waren: 12,5; 25; 37,5; 50 und 62,5 mm.

Die zweite Versuchsreihe dauerte 3 Jahre. Bodenvorbereitung — wie oben. Beschickung: 5, 10, 15, 20 mm unverdünnter Gülle pro Jahr. Eine einzelne Beschickungsdose betrug 40 mm verdünnter Gülle, entsprechend 2,5 und 5 mm unverdünnter Gülle (Verdünnung 1+15 und 1+7). Im Vorfrühling und Spätherbst, wurden die Dosen auf 20 mm herabgesetzt, bei einem Verdünnungsverhältnis von 1+3 (5 mm Rohgülle).

Feststellungen: Die Beschickungen mit Dosen von 50 und 62,5 mm waren zu hoch und der Abbau von Verunreinigungen unbefriedigend. Der BSB_5 sank von 3480 auf 480 mg/dm^3 O_2 herab; bei einer Stickstoffkonzentration in der verdünnten Beschickungsgülle von 1672 mg/dm^3, war im Ablauf hauptsächlich organischer Stickstoff und Ammoniak-Stickstoff vorzufinden. Der Abfluß war grau gefärbt und stinkte übel.

Im nachfolgenden 3-jährigen Versuch, in welchem die Lysimeter wesentlich schwächer belastet wurden, war der Abfluß klar und geruchsfrei. Der höchste, notierte BSB_5-Wert betrug im Ablauf 170 mg O_2/dm^3, bei Jahresmittelwerten von 4,9 — 19,7 mg O_2/dm^3. Der Stickstoff war vorwiegend in der Form von Nitraten.

Somit ist erwiesen worden, daß der Abbau von Gülle im Boden grundsätzlich möglich ist, daß aber der Reinigungsgrad von der Gesamtbelastung pro Jahr und von den einzelnen Beschickungsgaben abhängig ist. Je höher die Belastung, desto höher die Konzentrationen von N, P, Na, Cl, Mg und BSB_5 im Ablauf. Nur die K-Konzentration war ziemlich konstant und überschritt den Wert von 0,5 mg K/dm^3 nicht. Bei Beschickungsgaben von 40 mm verdünnter Gülle, hält der Boden alle Schwebestoffe zurück und baut den BSB_5-Wert und P_2O_5 um mehr als 99% ab. Der Abbau von Stickstoffverbindungen war entsprechend niedriger und betrug mit zunehmender Belastung 80,8; 68,8; 65,7 und 60,2%; bei Bewässerung mit NPK — 91,8%. Kaliumwerte wurden um 78,9–84,9% reduziert, unabhängig von den Belastungsparametern.

ИССЛЕДОВАНИЕ ОЧИСТКИ СВИНОВА НАВОЗА В ПОЧВЕ

Автор провел лиземетрические опыты с орошением луга на легкой унавоженной почве. Длящееся год исследование состояло из таких комбинаций: NPK — 280+100+200 кг/г, 10,20,30,40 и 50 мм навоза в год. Применяемая для орошения навозная масса поступала разбавленной, а величина единой дозы составляла 12,5, 25, 37,5, 50 и 62,5 мм. В течении последующих трех лет опыты имели следующую комбинацию: NPK — 280+100+200 кг/г, 5, 10, 15 и 20 мм навозной массы в год. Орошение проводилось 40 мм порциями разбавленной навозной массы, которые содержали по 2,5 и 5 мм навоза (разведение 1+15 и 1+7), а ранней весной и поздней осенью 20 мм порциями, содержащими по 5 мм навозной массы (разбавление 1+3). Сток с почвы после орошения порциями навозной массы 50 и 62,5 мм, биологическая потребность кислорода ($БПК_5$) которых составляла 3480 мг/дм^3 а концентрация азота 1672 мг/дм^3, обнаруживал признаки большого загрязнения. Его $БПК_5$ составляла 480 мг/дм^3, а азот выступал главным образом в форме органических соединений и аммиака. Этот сток имел серую окраску городских стоков и неприятный запах. В трехлетнем эксперименте, в котором использовавшиеся единичные порциисодержали 40 мм навозной массы и нагрузка почвы навозом была гораздо меньше, сток был прозрачный, без запаха. Его максимальная $БПК_5$ составляла 170 мг/дм^3 а среднегодовая 4,9–19,7, азот выступал, в основном, в форме нитратов.

Полученные результаты показывают, что очистка навоза в почве зависит от величины используемых порций и годовой нагрузки. С увеличением нагрузки почвы навозом в почвенном стоке увеличивалась концентрация азота, натрия, кальция, хлора и магния, а также $БПК_5$. Только концентрация калия выдерживалась на постоянном уровне и не превышала 0,5 мг/дм^3.

Использование 40 мм порций разбавленной навозной массы полностью обеспечивало очистку навоза в почве, а редукция $БПК_5$ и P_2O_5 поднималось выше 99%. Степень редукции азота была значительно ниже и в зависимости от величины нагрузки почвы навозной массой достигала 80,8 68,8, 65,7, 60,2% при орошении NPK — 91,8%. Величина нагрузки почвы навозом не оказывала особого влияния на процент редукции калия, который менялся в пределах 78,9–84,9%.